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LIGHT:

A LECTURE

BY

THE REV.

THOS. ROMNEY ROBINSON, D.D.,

ASTRONOMER ROYAL FOR IRELAND.

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LECTURES

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Dublin Young Men's Christian Association

IN CONNEXION WITH

THE UNITED CHURCH OF ENGLAND AND IRELAND,

DURING THE YEAR 1862.

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DUBLIN YOUNG MEN'S CHRISTIAN ASSOCIATION

IN CONNEXION WITH THE

UNITED CHURCH OF ENGLAND AND IRELAND,

IN THE

METROPOLITAN HALL, NOVEMBER 26TH, 1862.

HIS GRACE
THE RIGHT HON. AND MOST REV. MARCUS GERVAIS BERESFORD, D. D.,
LORD PRIMATE OF ALL IRELAND,
IN THE CHAIR.

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LIGHT.

In the oldest and most precious of records, we are told that "God said let there be light! and there was light! And God saw the light that it was good." In these few words how much is contained: much that the wisest of our race can never fathom—much that, perhaps, no created being can ever know. And, on the other hand, how much does our entire being bear witness to their truth: the animal instincts of our nature; its poetic and imaginative elements—its highest flights of science—all tell, in thankful harmony, that "light is good."

Let me, my young friends, invite your attention, while I try to lay before you a few facts in illustration of this great truth: not intending to give them in the detail which would be required were I seeking to teach you Optics, but rather wishing to point out to you certain lines of thought, which you can follow at your leisure; and which I hope will, if carefully traced, bring to your minds the same intellectual pleasure, and the same consciousness of the ever present love and power of our Creator, that they have done to mine.

In the first place, have you ever speculated on the condition of man if light had not been, supposing he could have continued to live in such a case. The sad words of almost the

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greatest of our poets, "knowledge at one entrance quite shut out," very faintly shadow forth our loss; for that entrance is many times wider than all the rest: it is by sight that we know of all that is not in actual contact with our bodies. The sense of smell might give some feeble information of some things beyond that limit, as it warns the deer to fly or the hound to pursue; the sense of hearing might give some imperfect notion of direction and of distance through a range something wider; but even with their aid, we should have been beset by inevitable dangers, and unable to acquire or apply any of those wondrous powers by which we bend inferior creatures and even elemental forces to our will. Imagine ships guided in a storm, complex machinery worked, or even iron forged by sightless men. And we are not to estimate the whole weight of this privation by what we note in those among us who are afflicted by want of this sense. They learn from those around them, the existence of vision and many of its results; and are assisted by *their* knowledge in endeavouring to supply their own defect. In this they sometimes succeed so as to excite surprise; but never so far as not to feel that there is a dreary interval between them and their fellows. And the intellectual disadvantages are not less than the material. I say nothing of the loss of that beauty which is now so profusely poured over earth, sea and sky, or of what is commonly called art, architecture, painting, or sculpture; but literature and science in many of their most important branches could not have existed. Whatever depends on the use of letters must have been limited to some few words which could be felt impressed on clay or some other soft material; or, perhaps, embossed like the volumes which, in our own time, have been devised for the instruction of the blind. Each generation would, therefore, have no profit from the wisdom or experience of the past, and mankind would be fettered within the circle of the present and incapable of progress. We could have no knowledge of astronomy, or all that development of geometry to which it led; none of geography or chemistry—very little of natural history, and so on through the whole circle of inductive knowledge.

Secondly: without light man, constituted as he is, could not have *lived*, and the scripture sayings which so often connect light and life, are as true in their literal as their spiritual meaning. In fact, its presence is so generally connected with every kind of life, that it may safely be inferred that the few apparent exceptions will disappear on more careful research. Without insisting on the blighted and unhealthy look of children reared in ill-lighted dwellings; or the statements that some of those animals which pass through certain stages of development, have been found to remain imperfect if kept in darkness, I will refer you to the necessary connexion which light has with the nourishment of plants, or at least the great majority of them. These beings are, in the main, composed of four elements, two of which they get from the atmosphere, but not directly. One of these, nitrogen, is not essential to vegetable life; but the other, carbon, is indispensable. As it exists, combined with oxygen in the air, in the state of carbonic acid, it is soluble in water, and thus is taken up by the roots and transported to every part of it, specially the leaves. Now, in these is found a peculiar substance which gives them their green colour; and this has the remarkable power of decomposing carbonic acid under the influence of light; the oxygen is exhaled by the leaves, and goes to replace that which is consumed by the breathing of animals; but the carbon is retained in the tissues and secretions of the plant. If the plant be removed to complete darkness it soon perishes, becoming white, and losing any savour or odour which it had possessed. Were, therefore, light absent, every green herb, every tree, every moss, and liverwort, would vanish from the face of the earth. There are some of the lower limits of the vegetable world in which this agency of light is at least doubtful: such as the various kinds of mouldiness; but these grow invariably on dead or dying organisms, which it is their appointed office to consume, and thus *they* are provided with food in another way.

Now the food of all animals, man included, is ultimately of vegetable origin—many of them prey on others through several successions, but at last we must come to the plant-eaters. As far as I know there is not a single instance of any animal, however low in the scale, which can be nourished by *inorganic* matter—matter which has not been modified by the transforming influences of at least vegetable life. I have heard, indeed, of specimens of the common mite being found in solutions of flint or of nitrate of silver, but I suspect it was very much against their will, and that they did not thrive there. From all this it is evident that had darkness continued to shroud the earth, it must have remained waste and void of every thing belonging to the present types of existence; it is, therefore, with perfect propriety that in these annals of creation, light precedes life. And it is not less notable, that none of the facts which I have used to show that propriety were known for scores of centuries after these were written.

Let us next try to understand, however imperfectly, what *was* ordained by the command—"Let there be light." This inquiry includes the various sources of light, its properties, and its nature; a vast field which every year is extending, and which few are able thoroughly to explore. A very limited survey of it is all I can offer you. The great fountain of light on earth is the sun, whose production of it almost infinitely surpasses all others: the stars have the same luminous quality, but from their great distance, as I shall soon explain, their splendour is comparatively insignificant. *How* these bodies shine we cannot tell. I have no difficulty in conceiving that if God had pleased to will that they should send forth light, they must do so as a *primary* effect of that Almighty cause; but he seems to have not done so; and to have appointed intermediate agencies, by which, as a secondary or even more remote effect, this result is produced. When the sun is studied with a powerful telescope, we find appearances which indicate that violent changes are going on at its surface; and there are variations in the light of some stars; which lead us to conjecture that even these mighty luminaries belong to the same analogy as our feeble lamps. It would, however, be a silly dogmatism which would narrow that analogy so as to make it a perfect correspondence, for it is highly probable that the forces which act on the atoms of our earthly matter are not the only ones in the universe.

Let me point out to you one probable reason why the Great Author made light to be a secondary effect of causes, widely diffused, and thus attainable wherever those causes are present. Had light belonged exclusively to the sun and stars as an immediate effect of the Divine will, the inhabitants of earth, must, for nearly one third of the year, been in absolute darkness; but as it *was* appointed, man can obtain it for himself, limited indeed in quantity, but amply sufficient for many of his wants. And this is common to every case of its production—that it comes from an expenditure of some force; that it is, in fact (as occurs in many other similar cases), merely a transformation of power. The first and chief of these causes of light is heat. If a body be heated in the dark, at a certain temperature it becomes visible, looking red; increasing the heat—yellow; and at last white; continuing to shine as long as the heat lasts. It is remarkable that vapours and gases are far less capable of this effect than solids; so a stream of the former, though intensely heated, may scarcely be visible; while a fragment of solid matter introduced into it becomes intensely bright. This is exemplified by the Lime Light; which ought to have a special interest for us, as it was invented for the Ordnance Survey of Ireland. The officers who conducted that great work, feared, that in our humid climate, their distant signals might not be visible, and it was committed to a young man, afterwards well known among us as Captain Drummond, but ever a leading intellect among his fellows, to provide against this danger. It was first tried on Slievesnaght, the loftiest mountain in Donegal, and observed from Divis, near Belfast; and though their apparatus was merely extemporized, it was seen at once, though the sun was above the horizon, after they had failed during five weeks in even getting a sight of the mountain itself. The second cause is chemical action. When two bodies, having certain different qualities, are brought into intimate contact, they unite and form a compound, possessing new properties. The forces which are expended in producing this change, are not destroyed, but transformed into other energies, of which light is one. As heat is also generated at the same time, there may be some doubt whether it is not the immediate origin of the light; but there are cases where this can scarcely be supposed. Many of you may have seen decaying wood shining in the dark, or phosphorus in air at common temperatures: in both of these the heat evolved seems quite inadequate to make the substance luminous. To these and the preceding belong nearly all our means of producing artificial illumination. A gas or vapour (obtained by heating some oily matter) is ignited sufficiently to make it combine with the oxygen of the air. A portion of its carbon is at first set free, and this, by the heat which is evolved, becomes bright. These combustibles, however, though most convenient, are not what give the most intense light; in this respect they are far below some metallic compositions used in fireworks, and some of the elementary bodies, as boron or phosphorus. The third cause is vital power: we know very little of this mysterious energy, but yet there is good reason to admit that it occasionally produces light. Without insisting on the somewhat doubtful accounts of flowers emitting flashes at certain moments of their developement, it seems established, that some rhizomorphous plants do shine in the dark. The little luminous scolopendra is not uncommon in Ireland. All have heard of, and I dare say many of you have seen the glow worm; the fireflies of southern Europe figure in books of travels, and the far more brilliant ones of Surinam and Brazil have even been used instead of lanterns. The sea swarms with luminous creatures and its shining has even averted shipwreck by revealing breakers in the vessel's course. In the case of animals the light depends on the creature's will, exhausts its strength when too long displayed, and then is not shewn again till it is rested.

The last cause of light is electricity, though here also heat is is simultaneously produced. Electricity is but another of those transformations of the forces implanted in matter by the Creator's will. It is generated by mechanical force producing pressure or friction, by heat, by the vital power of some fishes, by muscular contraction, by magnetism, and above all by the action of chemical affinity. When this last force is made to act in an apparatus called from its inventor the Voltaic Battery, the electric power produced is enormous; and when made to pass through gases or vapours, it evolves a light only inferior to that of the sun in intensity. [*Spark of Induction Machine and Voltaic Light*]. In this instance the electricity streams between points of prepared coke, and sweeps from them a flow of carbon in vapour, which gives this dazzling light. Its flame is the brightest, but many of the metals are also very brilliant. This potent illumination is slowly coming into use, and probably will soon become common, at least for special purposes. One of these will readily occur to some of you—the light-house; where even an added mile of visibility, in fog or snow, might save many a good ship and her gallant crew. The complex character of the Voltaic Battery has hitherto been the avowed objection; but recently the electricity has been as effectually obtained for such work by a combination of magnets, which merely requires mechanical force to excite it.

Having thus gone through the modes of obtaining light, let us consider some of its most important properties. The most elementary one is that it travels in straight lines, as every one's experience tells him. Hence it gives such precise knowledge of the direction of an object, and of its figure. Had it travelled in curve lines the surveyor could never have mapped a field, nor the painter represented a form without complex calculations. The astronomer has a little specimen of this, arising from the refraction of the stars, which though very little, gives him much trouble. I may be excused for mentioning another consequence of this property, which is connected with astronomy. From this a very little mathematics will show that the intensity of light diminishes as the square of its distance from the luminary increases. In fact the light which falls on a square foot at a given distance would, at twice that distance, cover a square of two feet: that is, four times as great, and therefore each square inch of the latter would have but one-fourth of the light on a square inch of the former. This will explain the enormous difference between the sun and the stars. Astronomers have proved that one of our brightest northern stars, Alpha Lyræ, is 587,972 times more remote than the sun; therefore, if of the same size and intrinsic brightness it must appear to us 345,712 millions fainter; so that we may rather wonder it can be seen at all. This principle gives an easy method of comparing lights, removing the more powerful, till they seem equally bright, or rather their shadows equally dark; the squares of their distances give the proportion.

2. Light, from whatever source, moves with the same velocity, and that (according to our notions) a most enormous one; so great that it would go 7.77 times round our globe in a second. For all purposes of man's ordinary pursuits it is instantaneous; but even *it* is slow in traversing the vast profound of the heavens. It requires 9.18 years to reach us even from that bright star I named; and how long would it be in travelling from some of those which Lord Rosse's telescope reveals. And yet, through all that almost unfathomable distance, *the very passage of light* tells us that God is there.

3. I said that light travels in straight lines; yet it can be turned out of its course. Suppose it is passing through air, and that it comes obliquely on some denser body with a smooth flat surface, a portion enters the body, but the rest is turned back, this is said to be reflected. If the smoothness amount to polish, it goes off at the opposite side, making an angle equal to that at which it met it; this is the law of reflection—if not, it is scattered in every direction; and it is by scattered light that most bodies are seen, for without it only self luminous objects, or those between a luminary and the eye could be visible. Their power of producing this effect is very unequal; a plate of polished silver reflects almost completely; but the same when smoked over a flame, not more than two or three per cent. That portion of the light which enters the body is apparently lost there (or rather becomes some other power, as heat or chemical force). Such bodies are said to be opaque; others are pervaded by the light with comparative ease; but in this case it is bent aside, according to another

definite law, which enables the mathematician to predict its course. This is called refraction, and by our knowledge of it and reflection, we are able to govern this etherial existence, and make it work our pleasure. Take three striking instances. I have already referred to the lighthouse. I suppose you know the arrangements of these beneficent structures; you may easily do so, for your own harbour and its adjoining shores afford several magnificent examples of them. They are designed to give the sailor means of knowing his position at night, when approaching any danger, and therefore it is necessary that he should see them as far as possible, and know them when seen. Now as light diverges in receding from its source, it, as I have already shown you, becomes faint, so that even the electric light would be invisible at twenty or thirty miles distance; but we can reflect and refract nearly all these diverging rays into one intense beam, where they are almost parallel, so that, practically, they are seen at any distance. And as nothing is visible outside this beam, if we make the apparatus which forms it revolve parallel to the horizon, it is visible at intervals of certain seconds or minutes, the number of which tells the name of the light house.

Again, you wish to examine an object which is too small for you to discern its figure, or even its presence. If brought closer to the eye it would seem larger, but then the eye could not bring its light to the condition necessary for distinct vision. That organ, however, can be aided by an additional refraction of the light, and with the help of convex lenses we can see the object perfectly, even when a hundred times nearer, and, therefore, larger; we, in fact, apply a simple microscope. Or, thirdly, the object is invisible from distance or from faintness; here we use glasses which imitate the eye, and form in their focus pictures of what is before them. These pictures are small; but then you can examine them with a microscope and magnify them at pleasure. In doing so, however, you make them fainter; and, therefore, must contrive to get more light. And this is easily done. The eye sees each point of its own pictures by a beam of the same diameter as its own pupil—say a fifth of an inch; but that which illuminates each point of the instrumental picture is as large as the glass. Now, if this were a foot in diameter each point of the picture would be eighty times brighter than to the unaided eye; this glass is, in fact, a giant pupil. Here is the secret of the telescope; and its power of accumulating light will at once account for the marvellous facts which it reveals, especially, when of the stupendous bulk that it has attained by the combined genius and science of our illustrious countryman, Lord Rosse, where the pupil is no less than six feet in diameter. I have chosen these illustrations out of many, merely glancing at them; but the subject is of great extent and great interest. Even these three would give ample room for three lectures; and I would point them out as fitting subjects to some of the many friends of this Association, who are competent to the task. They should be preceded by one on the Eye itself, the most wonderful of all optical instruments.

4. The study of refraction disclosed to Newton an unexpected fact, whose consequences seem to stretch out in almost endless variety. All light is bent aside by refraction, but all is not equally bent. This difference is inherent in the nature of the several rays; and it has been ordained by the Creator, that so differing they shall also produce different impressions on the eye. Those which are least refracted cause the sensation of red; those which are a little more so, orange; and as the refraction increases, the color passes through yellow, green, blue, and violet, till it fades away. The experiment is easy when we can command sun light. It is admitted through a narrow slit into a darkened room, and forms a picture of that on

a white screen. Let now a piece of glass with two inclined polished surfaces, a prism as we call it, be interposed in its course, the rays are turned aside by the refraction at each surface, and the screen must be shifted to receive them. Were all equally deviated the image of the slit would be unchanged, but, instead, while its height remains the same, we find that its breadth is drawn out into a band brilliantly coloured, which is called the spectrum. At this hour the sun will not serve us, but I hope the electric light will be more obedient. It is now excited in a lantern provided with a narrow slit, which is sometimes placed in the focus of a lens, so as to send from it a beam of nearly parallel rays. These pass through the prism, and then through another optical combination, which forms on the screen a picture of the spectrum. This arrangement has, within the last two years, become well known as the spectroscope It is obvious that any flame may be substituted for the Voltaic; but scarcely any other is bright enough to give a picture on the screen, and their spectra can only be examined with a telescope. You observe that there is no abrupt separation of the colours—each tint passes by beautiful gradation into the next. But it is generally stated that there are seven principal—latterly, the highest authorities seem to reduce them to three, red, yellow, and blue, and suppose the orange to be a mixture of red and yellow, the green of yellow and blue. This fact of coloured rays at once explains a multitude of phenomena. As all bodies reflect part, and transmit or absorb part of the light which falls on them, it is evident, that if these actions are not equal on all the rays they must appear coloured even in white light. A piece of red cloth held in the red and blue parts of the spectrum looks bright red in the one, but a dusky brown in the other. Or, if it transmit some, absorbing the rest, it will shew the colour of the first, as red or blue glass.

I might point out other not less striking consequences for many an hour, but I have, I hope, said enough to induce you to take up the enquiry yourselves. I will, therefore, dismiss this with one remark. It is perfectly possible, as we shall see, to conceive a state of things in which the sun should have sent out only rays of one refrangibility; still more so, that the eye should have only been sensible to the presence of light in general, without perceiving the difference of its rays. In fact, such cases actually occur *now*, though very rarely, while the more limited incapacity of distinguishing between red, yellow, and green, is not uncommon. Had either of these things been ordained, how much of pleasure, of beauty, of those feelings that when one looks over a lovely landscape or at a glorious sunset, make his heart glow within him, and raise his soul to high and holy thankfulness, could not have been. Can we fail to acknowledge that what we feel so deeply was designed for *us*, or can we possibly suppose that it was not in reference to the moral influence upon *us*, among its other wondrous powers, that God declared the light to be good.

5. Marvellous as the eye is, its powers come from no natural necessity of the case; and there is much *light which it cannot see.* Of the rays which come from the sun, and from, I may say, every other known source of light, there are many quite invisible, though differing, as far as we know, only in refrangibility from those which we see. Outside the red, and of about the same extent as that colour, are rays which affect touch not sight, rays of heat, which explains the connection between visible light and heat that I have already mentioned. Outside the violet, are others equally invisible, but possessing peculiar chemical powers. Their extent is variable; in some electric lights twelve times as long as the visible spectrum.

They make our photographs; but, doubtless, they play an important though yet undiscovered part in the order of life.

6. You saw that the Voltaic spectrum was continuous like a variously tinted ribbon; but this is not always the case; it is not so with the sun's light. Its spectrum is crossed by some thousand fine dark lines, each of which denotes the want of a certain definite ray. That want may arise either from such ray not having been produced, or from its having been absorbed by some medium through which it passed. You saw how the cobalt blue glass absorbed all but red and blue; and the action of some vapours is even more analogous. And many spectra are interrupted in another way, not by dark but by bright lines, which occasionally contain all the light, appearing widely apart on a dark ground. These are best obtained by introducing certain metallic compounds into a hot flame, which gives of itself very little light; but they are not bright enough to be projected on a screen. You can, however, know the predominant ray by the colour of the flame (chlorides of sodium, copper, and strontian. But when introduced into the Voltaic flame, the bright line of metals are seen *on* its bright spectrum, and, therefore, their dark intervals cannot be traced. One of these, silver, we may exhibit. From this it follows, that the presence of a substance may often be recognized merely by introducing into a flame any body which contains it, and examining the spectrum. It need not be in the metallic state, and it is found by trial that in some instances an amount can thus be detected, of which no other method of examination could give the faintest sign. For instance, there is a very rare metal, Lithium (I believe the lightest of all known solids), which is found in very small quantity in two or three scarce minerals. It was found, however, by the celebrated German chemist, Bunsen (who first contrived this new spectral analysis), that its light has a brilliant red line given by no other sub-

stance. Well, with this test, he found it very commonly diffused. He traced in the waters of the ocean, in the granite of his country's mountains, in plants, in the milk of cattle, and in wines, mere traces, certainly, but yet sufficient from the abundance of the crude materials containing it, to be an object of commerce. Its red line is quite different from that of another alkaline metal, Strontrum, whose flame I have shewed you. Bunsen was not a person to leave unemployed the powerful instrument which he had made, and it has already given him two metals. One of these gave two intense blue lines, from whence he named it cæsium; the other, besides two violet, has two very deep red, whence it is called rubidium. In the same way, Crooke, an English chemist and distinguished photographer, has found in a residue of impure sulphur a metal, Thallium, remarkable for having in its spectrum only one line of dazzling green. You will, I think, agree with me, that wonderful as Light is, it was scarcely possible to have conceived beforehand that it had in reserve such a marvellous illustration of its appointed task—to reveal to us the remote and obscure. Yet even a more daring flight has been taken on its wings. It has lately been discovered, independently, by several philosophers, that a medium which *emits* a ray of any kind *will not* (within certain limits) *transmit that same ray if it come from another source.* A familiar illustration of this is given by a flame containing the vapour of sodium, for instance, such as that which I have shewed you. In the prism it shows only a bright double orange line, and little else. Now if you look at any continuous spectrum, as of the lime or electric lamps, and then interpose the soda flame, instead of seeing the orange lines on the bright ground, you see two fine black ones exactly where they should be. This experiment is not an easy one, but some other substances have been tried with corresponding results. Then for the application of this. If you found in any spectrum two fine black lines *exactly where the soda lines should be*, and if it were possible that soda vapours could be between you and the light, it would be highly probable that soda is there, and that these lines are caused by its absorption. Now two such lines, precisely, are found in the sun's spectrum; and as we know that it has a very extensive atmosphere, and that the heat at its surface is so excessive that not sodium only, but all our earthly metals, could only exist there in vapour, it is thence inferred, that sodium, in some form, *is* present there and in considerable quantity, for a small portion would not have power to destroy rays so intense. The same conclusion must be made with respect to some other metals, whose spectra contain bright lines corresponding to dark ones in the solar spectrum. The most notable of these are iron, so common on earth; magnesium, also common here; chronium and nickel, both comparatively scarce with us. If this be well established, it is a singular fact, that these four metals should be so abundant in the sun; and, at the same time, should occur in those strange bodies which fall from our atmosphere, and which some philosophers suppose to play an important part in reference to the sun itself. Nor is it less remarkable that two at least of them are highly magnetic, and that the sun exerts an influence on the magnetism of our globe. But much remains to be done before this investigation can be accepted as absolutely above dispute; and supposing we succeed in this, yet more remains, for we must go much further, even to the stars, some of which shew spectral lines quite different from those of solar light.

But I must stop, though there remain other properties of Light, such as interference, refraction and double polarization of endless interest and beauty; yet, I have indicated to you enough to make you ask what is the nature of this subtle agent, what is the elaborate play of mechanism that gifts it with its varied powers? It was long supposed to be an accident of matter, an explanation darker than ignorance itself. Then to be a stream of atoms almost infinitely small, shot forth from luminous bodies: this accounts for some facts, but fails with many more. One capital one suffices to disprove it; according to it, a ray moves faster in a denser medium, than in a rarer; for example, faster in water than in air. Now, considering the enormous speed of light, it might seem hopeless to measure it; but it has been done, and we find that it is retarded in the water. The only other hypothesis that has been formed, is, that light is not a substance, but a mere form of motion, in fact a wave. All are familiar with this peculiar propagation of impulse; throw a stone into a pond, and a circular wave rolls from it in every direction; twang one end of a long stretched cord, and you see the bend run along the line. From these we pass to other undulations which we cannot see, but know by their effects: sound is a wave of the air; earthquake a wave in the solid rock that is below our feet. These various vibrations have each its peculiarity, but they all agree in this thing, that the velocity of each is always the same, while the medium is unchanged, one of light's most striking properties. Light's analogy with sound, probably first suggested that it also was a wave, and a wave in a elastic medium. In consequence, the characters which on this supposition it ought to have, were carefully investigated; a work requiring mathematical powers of the highest order, and in which our famed countrymen, Hamilton, Lloyd, M'Cullagh, and Stokes, are among the most distinguished. In many instances this theory explains observed facts, in many predicts them, in none is it inconsistent with them; and in the cases where it seems to fail, there is no reason to doubt that future research will remove the difficulty. According to every rule of philosophising, therefore, we must accept this supposition as true. But then comes the next question, what is this elastic medium, of which light is as it were the sound? this ether as we call it, that we may describe it in a word instead of a sentence? We do not know; though we are sure of its existence. But some of its attributes are manifest enough. Its extent is as wide as the starry universe, perhaps much wider, for it must be present wherever light can pass. If there be in it any matter, it must be inconceivably fine; for the passage of light, also shews, that it is in the densest crystal, as in the rarest gas; and, at the same time, the forces which reside in its atoms, and produce the velocity of its waves, must be almost infinite. This, then it was, which came into being, when "God said, let Light be;" and with it, not light alone, but its other powers, heat, magnetism, and probably a host of others, of which we see, as yet, only glimpses, but all of which are ministers of the will of the Most High, filling earth with life and beauty. But the might of its inherent forces wakens still loftier thoughts; whence come *they?* Each point of this immeasurable ether is held at rest by its own forces, acting on those of its neighbours; they remain still and balanced, but the slighest displacement of any one of them, calls into action their stupendous energies. How is this? The mere materialist will rig up some ideal machinery of atoms streaming through space; but this will not do, for all our knowledge of these atomic forces implies action *at a distance; and, therefore, where matter is not present;* nor is there in the whole range of science any fact indicating that two atoms ever come into *actual contact.* The unbeliever who wishes to mask his denial of God's government of the world by a pretence of science, will tell you, that these powers belong to the *nature* of the ether, are an essential condition of its existence. Such phrases are mere jargon, words that darken knowledge. For what is nature? As these persons probably understand it, it is merely that assemblage of things and qualities which exists around us. Now, if you ask them for instance, the *nature* of a crystal, they must tell you its angles, its composition, its optical properties, and whatever else they know of it; but if they then say, that this nature gave it the forces which fashioned its angles, or united its elements, they are at variance with common sense. *Their* nature is only a name, and a name is not a creative power. The Christian's nature is the order of things which God ordains; but still the word is only the expression of an effect, not a cause. Too many of us *do* speak of nature and providence, or even heaven as personalities, but this arises from a mistaken reverence, an unwilligness to name too freely the great Lord of all. This is unwise, for if we think of Him as we ought to do, and speak as we think, we need have no apprehension. In that spirit, then, I say, that when God said, let Light be, He willed these forces, and that they exist at this moment, as emanations of His power, and in no other way. But there is another form of partial unbelief which asserts that the physical world is governed by immutable laws, which, however, may have been at first established by a Creator, but he does not now interfere to maintain or modify them—I call this unbelief; it is practically such; for were it true, it would be useless to pray for any temporal blessing, since the course of events *cannot* be changed; but it also is a delusion, in fact, a gross abuse of words. For what is a law in the true acceptation of the word. It is a commandment from a sovereign to his subjects, to do or avoid a certain act, with promises of reward or punishment, as they obey or transgress. Its power depends on *his* will, and he repeals it when he pleases. Therefore no law is immutable, and no law can enforce itself. Compare this with the so-called physical law, and the difference is obvious.

Take, for instance, what I already described, the law of reflexion: it is that the reflected ray makes the same angle with the mirror, as the incident. Will any one say that the law is a law at all, but by a figure of speech, that it is a cause of the ray taking that course; or that it is anything but an expression of a fact, which may be a law to a *man* calculating the track of a reflected ray, but can have no effect on the light. And it is the same for all other so called physical laws; they are descriptions of things which occur, and cannot be causes. I have dwelt on this, though it leads me rather wide from my subject, because these two confusions about nature and law, are at the root of much of that infidelity which is it at present endeavouring to flood the land. With the conceited scepticism which would persuade us to accept its decrees, against the authenticity of the Bible as infallible, my present matter has no connection, but what I have said will, I hope, suffice to warn you against some other follies that are now in fashion, and which can only be accounted for, by a real and inevitable law, that "they who will not receive the truth are given over to a strong delusion, that they may believe a lie." One of these blind leaders of the blind, not long since, denied the resurrection of our Lord, because the laws of nature are immutable, and, therefore, this miracle, or any other, is impossible. Another thinks all the various plants and animals are made by what he calls natural selection, in plain English, nature's choice, helped by chance; these powers have fashioned man himself (may we ask soul as well as body) from perhaps a fish, perhaps a monkey; they have created our eye, with all its astonishing display of optic knowledge, its indications of design and purpose, from a fibre of nerve, and a speck of pigment. I presume, however, that the fibre and the speck, had some personal maker, and think he needed no help to make the eye also.

This all will perish, like many such former devices; but how many will be destroyed by its influence before it perishes! The real testimony of science is of a very different character: it sees in every truth which it discovers in the physical world, evidences of an intelligent cause; in every force, which it studies, workings of an immaterial power; and all its teaching centres in that great lesson which was given to the Athenian philosophers, by one who thoroughly understood the real purpose of man's being, and the highest object of his faculties. "God giveth to all, life, and breath, and all things." "For in him we live, and move, and have our being." There is, of course, much that we cannot understand with our limited powers of reason, much that escapes our present means of observation, many difficulties which we cannot yet explain, but nothing that is a justifiable cause of doubt, as to the ever-present action of our heavenly Father. In these words I speak the conviction of the best and wisest of our race, past and present, who have been blessed and enlightened by knowledge of created things sought in such a spirit, and sanctified with its perfect accordance with the knowledge of the Creator. May each of you study his works in the same spirit; and find in them evermore, fresh cause "to praise Him for his goodness" and declare the wonders that He doeth for the children of men.

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